Automatic Sun Burst Detection in Radio Spectra Data Based on Computer Vision Techniques

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Solar activities such as solar flares and CMEs influence the interplanetary space and they might also affect Earth's magnetosphere. Solar activities can be accompanied by solar radio bursts, the occurrence of which, together with other data can be a valuable input for space weather forecasts. An increasing number of ground-based observatories like e-CALLISTO network (http://e-callisto.org) around world gather radio spectra data on a continuous basis. This makes possible to continuously observe sun in the radio range, but also generates a huge amount of spectra data, making manual detection of the solar radio bursts a challenge. On the other hand, automatic detection of these solar radio bursts has its own challenges since the frequency range of solar radio bursts is heavily contaminated by interference from various radio transmitters or other electronic devices.

Various authors described automatic solar burst detection methods on e-CALLISTO spectra data. Afandi et al [1]. described an algorithm which sets conditions regarding intensity values on time and frequency channels. Singh et al. [2] described an algorithm which searches the contours of signals by using computer vision techniques and selects those that have a drifting tendency (a common feature of solar radio bursts which can be used to visually distinguish them from interferences) Kallunki et al. [3] also described a simple method which sums up the time channel and tries to find peaks which have drifting tendency.

In this work, we developed and tested a new automatic solar burst detection algorithm, mainly based on the method described by Singh et al. The algorithm was implemented on Python using Open CV library for contour detection. After applying median filter for background subtraction and later converting to a binary image, contours of the signals were retrieved. The area of each contour (A) was calculated. Smallest area contours and those briefer than 1s were discarded as they are not of interest. Later, for all the remaining contours found in the spectra, the following "slope" value (υ), eq. (1) was calculated.

$$\upsilon = \frac{f_{max}-f_{min}}{t_{max}-t_{min}} \quad (1) \qquad ASI = A\ x\ \upsilon \quad (2)$$

f_{max} and f_{min} are minimum and maximum frequencies in MHz, found among the maximum frequency values at each time channel of the contour. t_{max} and t_{min} are the global maximum and minimum time values among the points of the contour. Contours with $\upsilon < 0.81$ or $\upsilon > 162$ are discarded for either being too horizontal or too vertical, respectively, as suggested by Singh et al. For the remaining contours, an area-slope index (ASI) was calculated. (see eq. (2) above)

A data set of 1249 .fit archives from a random observatory chosen (GLASGOW) between the dates 01/07/2021 and 31/07/2021 (1 month of data), downloaded from the e-callisto website was used for testing the algorithm. 27 positives (archives which contain at least 1 burst) were identified manually. After optimizing the values of the ASI threshold and binary conversion threshold as 51 and 0,0001, respectively, the following results were obtained:

Total number of files analyzed	1249
Number of files with burst (Positives)	27
Number of files without burst (Negatives)	1222
Positives detected as positives by algorithm	20
Negatives detected as negatives by algorithm	853
General accuracy	70%

We find that the results are at an acceptable range for its utility in reducing manual labor. As a short discussion, the optimal ASI and binary conversion parameters found for the randomly chosen GLASGOW observatory are quite different from what the original author finds for the data set for GAURI observatory, due to very different interference characteristics at each observatory site and possibly different signal intensity calibration of the instruments. This makes necessary a parameter optimization for each observatory before using this algorithm.

[1] Afandi, et al., "*Burst-Finder: burst recognition for E-CALLISTO spectra*", 2020
[2] Singh et al. "*Automated Detection of Solar Radio Bursts Using a Statistical Method*", 2019
[3] Kallunki, "*An algorithm for the detection of low frequency solar radio burst*", 2020

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